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Discussion Paper

The Many Dimensions of Marine Environmental Quality

Raymond P. Côté

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FOREWORD

Recent evidence links an increase in deaths among beluga whales in the Gulf of St. Lawrence to a lethal build-up of contaminants in the fish they eat. The death of these mammals has alerted Canadians to the detrimental effects of the pollutants that have poured into our oceans for decades.

Most of the sources of marine pollution are land-based. Garbage, sewage, and toxic wastes reach the oceans through direct coastal dumping, rivers, urban and agricultural runoff, and rainfall carrying dissolved atmospheric emissions. Pollutants are also discharged by ships and structures such as oil rigs mounted on the continental shelf.

Whereas disposal of waste into the sea has traditionally been cheap and offered a ready, short-term solution to waste management problems, it poses a long-term threat of environmental degradation. And this threat is increasing.

In Water 2020: Sustainable Use for Water in the 21st Century, the report of a recent study completed by the Science Council on Canada's water resources, the relations between fresh water and the marine environment were identified as among the most evident and most serious unresolved research issues facing Canadians. Unfortunately, our understanding of the state of the Canadian marine environment is limited, especially in coastal waters, and our policies and programs for addressing the problems are still largely focused on symptoms rather than causes.

In response to this situation, and in recognition that concern over Canada's fresh water cannot be separated from the state of its marine resources, the Science Council's Water Resources Committee commissioned this paper. It is one of four discussion papers issued by the Committee on Water Resources; in it the author examines the state of Canada's oceans and reviews many of the key scientific, technical, economic, institutional, and other factors that must be considered if a resolution to the problems facing our oceans is to be found.

Raymond Côté is associate director of the School for Resource and Environmental Studies at Dalhousie University.

J.M. Gilmour
Director of Policy Analysis
Science Council of Canada

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Because most Canadians live inland, we do not think of ourselves as a maritime nation, and yet Canada has the world's longest coastline and one of the largest continental shelves on the globe. In 1987 Canada's oceans contributed more than $8 billion and 140 000 jobs (Fisheries and Oceans Canada, 1987b) to the economy. They support fisheries that are among the most economically valuable -- worth over $1 billion -- and socially useful in the world. Canada's oceans are used for transportation between us and some of our major trading partners, including Japan and Europe, and tourism and recreation on the coasts increase in value annually as people's disposable income rises. Although offshore oil and gas exploration is currently at a low level, the likelihood that hydrocarbon reserves do exist means that offshore production will occur in the future, and Canada's oceans will contribute even more to the economy.

The oceans are the source of much of Canada's wealth; unfortunately they have also become the repository for much of its waste. A large proportion of the population and the industry on the Atlantic, Arctic, and Pacific coasts discharge their wastes into the ocean, creating use conflicts and destroying the habitat of many species that contribute to the richness of the marine environment.

In 1971 the Science Council of Canada commissioned Stewart and Dickie to undertake a background study of marine science and technology in Canada. Perhaps the most disconcerting fact that arises from a review of their report is that many of the issues and recommendations for addressing them remain relevant 17 years later. Stewart and Dickie identified three principal motives for social, cultural, and scientific change:

- satisfaction of our natural curiosity about our environment;
- the desire to use the environment to enhance our quality of life; and
- recognition of our obligation to protect and conserve the environment.

They stated that:

> Nothing demands reliable prediction more than the effects of man's activities on his environment. There is thus a social need to develop high competence in the environmental sciences, a need which is independent of the usual "benefits" expected of scientific activities. It is our belief...that marine science is an essential facet of environmental science, and is to be developed and promoted as an essential part of our major responsibility for the control of environmental quality.

This report then is, in part, a status report on how we are dealing with the use and abuse of the marine environment 17 years after the Science Council's first study was issued. The paper also explores the international, jurisdictional, social, economic, legal, technical, and scientific dimensions of marine environmental quality issues.

What is the marine environment?

The terms "ocean" and "marine environment" have slightly different meanings. "Ocean" is defined as the salt water up to the freshwater limit including its physical and chemical characteristics and the organisms therein. "Marine environment" has a more comprehensive meaning. It includes the biological, physical, and chemical resources of estuarine and saline areas including sediments, intertidal zones, salt marshes, and the atmosphere above the ocean; in addition, human activities are part of the marine environment. For many, the definition also encompasses land and activities thereon that are directly influenced by the ocean and that have a direct effect on the coastal zone.

Marine environmental quality, then, is the state of the water, sediments, biota, and habitats in open ocean, coastal, and estuarine areas. This is consistent with other current definitions (Wells and Côté, 1988). Boelens (1988) has suggested that the quality of coastal waters is the ultimate

measure of the ability of a nation to manage its environment.

> Human activities, whether close to the sea or in the remote hinterland, have the potential to mobilize materials and energy which, through the intervention of natural processes, migrate steadily towards the oceans. During their passage, these materials are joined by countless tonnes of naturally eroded minerals and detritus which together form the remorseless flux of matter between the terrestrial and marine environments. Once in the sea, they may either contribute beneficially to the natural processes of the coastal zone or, depending on their qualities and characteristics, they may disrupt such processes or devalue marine resources and amenities.

These are the definitions upon which the following discussion is based.

Policy framework

The framework for Canada's management of the marine environment is complex because some responsibilities fall under federal jurisdiction and some under provincial jurisdiction and within each jurisdiction they are spread among various departments. To some degree, the jurisdictional boundaries are still fluid: this was shown by the recent decision of the Supreme Court of Canada on ocean dumping in British Columbia (R. v. Crown-Zellerbach, 1988), which is discussed under The jurisdictional dimension.

Two particular policies should be mentioned. The first is described in the document entitled Oceans Policy for Canada: A strategy to meet the challenges and opportunities on the oceans frontier released by the Minister of Fisheries and Oceans in 1987 (Fisheries and Oceans Canada, 1987a). The goals of this strategy are as follows:

- to maintain prosperous, dynamic oceanic industries that offer secure, steady employment and economic development benefits, particularly for Canada's coastal regions;
- to encourage world-class expertise and capability in oceans-related science, technology, and engineering, which together form the basis for future economic development of the oceans;
- to ensure ocean resources and the ocean environment are soundly managed and protected for future generations of Canadians; and
- to assert and protect Canada's sovereignty and sovereign rights over its ocean resources.

This strategy is generally consistent with the second policy, the federal environmental quality policy, which also applies to marine areas. This policy provides for:

- the integration of environmental and economic objectives;
- the development and promotion of environmental knowledge;
- the promotion and creation of protected areas;
- the prevention, clean-up, and control of pollution; and
- the communication to Canadians of the importance of a healthy environment.

In these and a wide range of other federal and provincial policies that influence the quality of the marine environment, the science and technology dimension is sometimes implicit and sometimes explicit, as is the case with the ocean strategy. The fact that it is there may well reflect a recognition on the part of government and industry leaders that development of the resources of this frontier area requires a solid scientific and technological base. However, we do not know whether the funding for R&D to support the sustainable development of marine resources and to protect the quality of the marine environment is adequate. The conclusion of many of the participants at the Canadian Conference on Marine Environmental Quality held in Halifax, 29 February-3 March 1988, was that current research and development is inadequate, especially interdisciplinary R&D.

Uses of the marine environment

Traditionally, marine areas have supported fisheries, shipping, and to a lesser degree

recreation and tourism. Coastal waters were also widely used as a waste receptacle in the belief that the oceans' capacity to assimilate wastes was inexhaustible. Mining, especially sand and gravel removal, also occurred in some areas.

Recently, coastal tourism and recreation in Canada has increased. Large numbers of Canadians visit coastal national and provincial parks as well as beaches. The population of recreational boaters, sailors, and scuba divers continues to increase. During the past 15 years, we have seen dozens of exploratory wells drilled on Canada's eastern and arctic continental shelves in search of new oil and gas reserves. More recently drilling has been proposed on the west coast. The search will intensify as land-based reserves dwindle and the price of a barrel of oil increases beyond $20. Shipping has moderated somewhat, though the advent of nuclear-powered ships raises concerns about contamination of the ocean's biota. With the designation of exclusive economic zones pursuant to the United Nations Law of the Sea, countries have begun to exercise greater control over marine fisheries, establishing intensive management regimes. These regimes have brought major fishing companies out of the red. The capture fishery remains economically and socially important on the three coasts, but mariculture is becoming a viable industry.

Until recently, ship-generated wastes, oil and chemical spills, ocean dumping, and industrial effluent discharges were the focus of pollution control efforts. Municipal sludge disposal already occurs in deep water along the east coat of the United States. Recently, Environment Canada approved a plan to dispose of an industrial sludge in waters on Canada's east coast. Greater attention is now being given to other land-based sources of marine pollution, atmospheric deposition of pollutants, and plastic debris.

The importance of scientific research as an ocean use and as a means of understanding climatic change, the effects of human activities, and the variability of ocean processes and production is increasing.

Future uses of the ocean are limited only by our imagination. Clearly, technology will have a major role to play in ocean exploitation as it has in space exploration. And several possibilities are on the horizon. Mariculture as a producer of fish for human consumption will continue to grow, barring unforeseen problems such as occurred in 1987 involving molluscs on the east coast. Research will expand the number of species that can be cultured.

New technologies involving sail power may influence shipping as we know it today. Non-energy minerals have become the subject of considerable interest, and the extraction of some chemicals from sea water has also been investigated. Alternative energy from the ocean has a recognized potential in Canada, especially because of the high tides in the Bay of Fundy and northern Quebec. A pilot project in Nova Scotia will have a major influence on any decision to proceed with a full-scale operation. In addition, wave generators and ocean thermal conversion plants are also under consideration and at least one coastal heat pump is now in use at a lobster holding facility in southwest Nova Scotia.

The disposal of industrial wastes by ocean incineration is now occurring in the North Sea, although it may well be discontinued. There has been pressure to use this approach off the coasts of the United States and possibly Canada. Research is also under way to assess the viability of disposing of radioactive wastes -- particularly from nuclear power plants -- on the seabed where the oceans are deep and sediments are stable.

Floating structures for accommodating residential and industrial uses are being designed: one floating hotel is now in place on the Great Barrier Reef of Australia, and floating airports and nuclear power plants have been proposed in temperate zones. The ocean and its resources already yield chemicals used in emulsifiers, adhesives, sealants, and waterproofing substances, and biotechnology will expand marine-based opportunities in treatment of wastes, fast-

growing food species, metal recovery, and pharmaceuticals.

In addition to moral and ecological reasons for preserving species and maintaining the integrity of marine ecosystems, there are social and economic imperatives for doing so. The marine environment has unexplored potential for maintaining and enhancing the quality of life of Canadians.

Pollution

Pollution is a deleterious impact on amenities, ecosystems, resources, human health, and legitimate uses of the environment, caused primarily by human activities. In the marine environment, it refers to health hazards; reduction of amenities; and harm to the integrity of marine ecosystems, to biota, and to the quality of water and sediments. The sources of pollution include sewage, urban runoff, agricultural runoff, fish-processing wastes, ocean dumping (primarily dredge spoils), coastal developments, petroleum exploration, chemical industrial effluents, pesticides, spills of chemicals and hydrocarbons, atmospheric deposition, and litter.

Waldichuk (in press) reports that in 1983 the authorities closed 262 shellfish-growing areas, covering 140 000 hectares in the Maritime provinces. On the coast of British Columbia, approximately 55 000 hectares were closed to direct harvesting of shellfish (Kay, 1987). The primary causes of these closures were municipal sewage, agricultural and urban runoff, and, to a lesser degree, boat anchorages. In many shellfish-growing areas, it is difficult to separate the impacts of the various sources of pollution and to know which one has caused an outbreak of disease. Although the consumption of shellfish from polluted areas poses a health risk, the shellfish themselves are not harmed by bacteria and viruses.

Industries have discharged, and in some cases continue to discharge, a wide range of industrial effluents into harbours, estuaries, and coastal waters. These effluents include materials with biological and chemical oxygen demand, suspended solids, metals, chlorinated hydrocarbons, and polycyclic aromatic hydrocarbons. Three situations warrant further consideration.

1. Although the discharge of some pollutants, notably mercury and PCBs, is no longer permitted, their use and disposal in the past has resulted in their accumulation in sediments. Under certain conditions, for example during dredging, these pollutants can be released into the water column and contaminate the biota.

2. Controls imposed on each industry (for example, oil refineries, pulp and paper mills, base metal mines) in a coastal area are generally established in isolation on the basis of best practicable technology and with scant attention to the cumulative impact of the deposits of all industrial and municipal wastes.

3. As more chemicals are identified and as toxicologists learn more about them, new concerns about chemical products and wastes arise. Examples are the chlorinated by-products of the bleaching processes in pulp and paper mills, the by-products of the chlorination process in municipal waste treatment, and tributyltin oxide in marine paints.

Many articles have been written on the effects of marine pollution but readers are referred to Waldichuk (1982), Waldichuk (in press), Wells et al. (1987), and Wilson and Addison (1984). Table 1 summarizes the environmental effects of different wastes and activities.

Loss of habitat and resources

For any particular harbour, the area of habitat lost and the consequent reduction in resource production over time is generally unknown. Although habitat degradation has been occurring since construction activities first began on our shores, it has accelerated during the past 25 years. Breakwaters, marinas, and port facilities have been built; harbours have been dredged and contaminated sediments have been dumped; coastal wetlands have been filled; and fibre and other material in effluents have smothered the productive bottom. In the past, this habitat has not been replaced, but future developers will be required under the federal fish habitat management policy (Department of

Table 1. Marine Environmental and Ecological Effects of Different Types of Contaminants and Activities

Contaminant or activity	Bacterial/viral contamination	Oxygen depletion	Toxicity	Bioaccumulation	Habitat degradation	Depletion of biota	Aesthetics
Sewage	X	X		X	X		X
Urban and agricultural runoff	X	X		X	X		
Pulp and paper mill wastes	X	X	X		X		X
Mining wastes			X	X	X	X	X
Ocean dumping	X	X	X	X	X		
Coastal developments	X				X	X	X
Petroleum hydrocarbon exploration and exploitation		X	X	X	X		X
Agriculture	X	X	X	X	X		X
Pesticides			X	X			
Petroleum refineries			X	X			X
Chlor-alkali plants			X	X			
Chemical spills and leaks		(X)*	X	X			X
Atmospheric emissions	X		X	X			
Food and beverage processing		X			X		X
Litter					X	X	X

* Potential for some spills and leaks.
Source: Waldichuk, 1988.

Fisheries and Oceans Canada, 1986) to set up enhancement or restoration programs to compensate for any damage to habitat.

Protection already exists for many critical migratory bird habitats along the coasts that have been designated as sanctuaries under federal legislation in accordance with international agreements such as the Ramsar Conventions of 1971. It is now clear how important offshore feeding areas for seabirds, marine mammals, and fish -- known as upwelling areas -- can be protected. Designation as marine parks or marine biosphere reserves are two possibilities.

Conflicts for space and between uses

Conflicts over marine space are intensifying as uses of the marine environment increase. In the last century, the two principal uses were shipping and fishing. Where risks were considered too high -- for example, near the entrance to major harbours, in narrow and busy channels such as entrances to the Halifax and Saint John harbours, and in log storage areas (especially on the west coast) -- federal regulations restricted large vessels to specific lanes in which fishing was banned.

Oil and gas exploration has also resulted in the establishment of exclusion zones around offshore drilling platforms. If proven hydrocarbon reserves are developed and pipelines are used to transport the oil or gas to shore, more exclusion zones will be needed. Mariculture will require limitations on access to some coastal waters. Perhaps unexpectedly, maricultural activity in some bays is opposed because it disturbs the natural beauty and peace of the area. Military uses, such as bombing practice, have led to intermittent restrictions on marine uses.

Conflicts will continue to arise as new uses infringe on traditional ones, and politicians and resource managers will have to respond. Processes do exist for resolving these conflicts, including regulation, negotiation, coastal zone planning, and sea-use planning. Information management systems and associated databases for coastal and marine areas will become increasingly important tools for those who must decide between uses. It will not be easy to resolve conflicts between legitimate uses, and new decision-making structures and compensation options may well be needed.

3. THE DIMENSIONS OF MARINE ENVIRONMENTAL QUALITY

The international dimension

The need for an international perspective on marine environmental problems has been recognized for many years. Shipping as an activity and pollution arising from it were the initial focus of international interest, resulting in several conventions and protocols. The first major international pollution control convention to address matters other than oil or other cargoes carried by ships was signed in 1972: the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (otherwise known as the London Dumping Convention) is the only global agreement specifically to address waste disposal in the ocean. The International Maritime Organization (IMO) of the United Nations continues to play an important role in the harmonization of shipping and marine pollution regulations and, through the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), in the evaluation of the scientific basis of marine pollution.

Marine fisheries on the east and west coasts of Canada are of interest not only to Canada, but also to the United States and other maritime nations, notably Japan, Spain, Portugal, and the Soviet Union. Agencies such as the North Atlantic Fisheries Organization and the Pacific Salmon Commission establish quotas and monitor catches for various commercial fisheries to ensure that stocks are conserved.

In part due to the impetus of the Stockholm Conference on the Human Environment in 1972 and the conferences leading to the United Nations Convention of the Law of the Sea in 1982, marine pollution and the capacity of the marine environment to accommodate wastes has received greater scrutiny by international scientific, consultative, and regulatory organizations. The London Dumping Convention and other agreements including the Regional Action Plans of the United Nations Environment Programme recognize that marine environmental quality depends on multilateral actions, including Canada's participation in international forums.

The jurisdictional dimension

On the national scene, the division of responsibility for the environment appears strange to many observers. It is often said that the federal government and the provinces have concurrent jurisdiction over the Canadian environment. Jurisdiction in marine areas has generally been regarded as reasonably straightforward: certainly activities in the water and on the seabed beyond the 12-mile territorial boundary are managed and regulated by the federal government, and even in coastal areas, much of the legal jurisdiction remains in federal hands.

Consider, for example, the March 1988 decision of the Supreme Court that the federal government has responsibility for control of marine pollution in Canadian waters (R. v. Crown-Zellerbach, 1988). In that case, the company has been charged under the Ocean Dumping Control Act, a federal statute, with dumping wood waste into waters of Beaver Cove, an area considered to be within the province of British Columbia. In ruling on the case on appeal, the majority of the judges ruled that ocean pollution was a matter of national concern falling within the peace, order, and good government power of the Parliament of Canada because of its extra-provincial and international character.

Thus, the federal government can exercise control over human activities, water quality, and fish protection in the sea beyond the low-tide mark and has, therefore, written regulations to control activities in navigable waters, to regulate the harvesting of shellfish in polluted waters, and to set standards and limits on some industrial effluents discharged into the sea.

However, to complicate matters, the provinces, as a result of their constitutional responsibility for civil and property rights, retain jurisdiction over environmental management of industrial and municipal

enterprises occurring on land, and some, notably Nova Scotia, New Brunswick, and British Columbia, have jurisdiction over some portion of the seabed. In Nova Scotia, management of some marine activities, such as aquaculture, has been transferred to the provincial government and this provides a precedent for similar arrangements with other provinces. The regulation and management of offshore oil and gas development in Nova Scotia and Newfoundland has been ceded to federal-provincial boards, which give the provinces new responsibilities.

This confused state of affairs has delayed the resolution of environmental quality issues in the coastal zone. More effort is required on the part of all levels of government to set aside jurisdictional debates, accept joint responsibility for the resolution of problems and cooperate in comprehensive assessments and integrated management plans for coastal areas.

The social dimension

Public participation

Although Canada began as a maritime nation, in which ship-building and fishing were major occupations, and although it still has the longest coastline in the world and one of the largest exclusive economic zones, nowadays most people think of it as continental, due to the large population in central Canada and the large volume of overland trade with the United States. This leads many Canadians to view the ocean from a romantic rather than a utilitarian perspective and explains the low priority that marine issues have for Canadian policy and decision makers. But the fact is that Canada's coastal regions, however widely they differ climatically, depend on marine resources to support their social and economic fabric. Fortunately, as current marine activities become more valuable and new uses become evident, the importance of public input, especially by users, into the development of policies is slowly being recognized.

Consequent development pressures in the coastal areas have resulted in conflicts between traditional and new users of ocean space and resources. This has been reflected in public debates about infilling of the shoreline on the east and west coasts, about log storage areas on the west coast, and more recently about the allocation of aquaculture leases in Nova Scotia. Local involvement in decision-making processes affecting marine areas will be critical to the success of coastal development and the management of marine resources. Shared management is a concept gaining acceptance in many circles. The Arctic Marine Conservation Strategy discussion paper released by Fisheries and Oceans Canada (1987d) states:

> Shared management is considered a prerequisite for conservation and effective management in the Arctic. Shared management is based on a sharing between governments, Arctic people and other stakeholders, of responsibility for making decisions about the use of renewable and non-renewable resources.

Greater participation in the planning and long-term management of marine resources has already begun. On Canada's west coast, at least three estuary management plans seek to establish an acceptable balance between environmental quality and continued opportunities for economic development. These plans have been compiled through consultation with government agencies at all levels, the public, and affected industries. These coastal planning exercises are the Fraser River Estuary Management Program, the Cowichan Estuary Management Plan, and the Squamish Estuary Management Plan (Langford et al., 1988).

Education

The resolution of marine environmental quality issues requires an interdisciplinary approach and the involvement of all stakeholders. To foster this type of approach we need to rethink our educational strategies. Traditional education tends to segregate perspectives and disciplines, with the result that some people see the solutions to environmental issues as primarily or entirely scientific, while others seem them as legal or sociological. No matter what the issue in question, few people are able to break out of the bounds of their discipline or

perspective, nor are they trained in techniques that permit them to do so.

Even though environmental issues have risen to the top of the political agenda in Canada, in a process that began in the early 1970s, Canada's educational systems have not kept pace. Few environmental programs exist at the university level in Canada and the interdisciplinary competence of their graduates has not been evaluated. Thus, it is not surprising that interdisciplinary marine resource management and marine affairs programs are only now receiving consideration. Although public awareness of and debate about ocean-related issues has been increasing, the United Nations Law of the Sea Convention was only finalized in 1983 and it has not been formally ratified by Canada. By contrast another milestone, the United Nations Conference on the Human Environment, was held in Stockholm in 1972.

Canadian universities have lagged far behind American ones in establishing programs of study in maritime affairs. In the United States, the Sea Grant Program, established by the National Sea Grant College and Program Act of 1966, has fostered research, education, technology transfer, and public information programs related to the use and management of marine resources. The program has spawned a network of marine-oriented scientists, policy makers, educators, and institutions comprising 22 Sea Grant colleges and seven institutional programs. Affiliations have been fostered with over 200 additional universities and marine research institutions, and over 3000 scientists, engineers, educators, extension workers, and graduate students are collaborating to advance knowledge and enhance management of the marine environment. For fiscal years 1983-87, Sea Grant's budget authorizations totalled $277 million (Côté et al., 1988).

Canadian universities offer only two interdisciplinary marine affairs programs and these are relatively recent. The marine affairs programs at Dalhousie University and the Université de Québec à Rimouski were made possible through core funding from the recently established International Centre for Ocean Development. However, the emphasis of these programs, due to the mandate of that federally incorporated agency, has been on assisting developing countries by providing education on the development and management of marine resources. The reasons behind the delay in educating the people needed to manage our marine environment effectively are not clear. Is there so much inertia in Canada's social, educational, and political institutions that we cannot be more progressive in newly emerging areas?

The legal dimension

Any consideration of the legal dimension of marine environmental quality must take into account international agreements, federal responsibilities, and provincial responsibilities.

International agreements are vital due to the fluid nature of the ocean, the lack of easily distinguishable physical boundaries between nations in the oceans, and the sea's quality of belonging to no one and to everyone. Treaty-making in the field of marine pollution, which began in the early 1950s, was spurred by the birth, in 1959, of the International Maritime Consultative Organization (now the Intergovernmental Maritime Organization).

Many international agreements and conventions apply to the marine environment. Canada has ratified the following:

1954 International Convention for the Prevention of Pollution of the Sea by Oil

1958 Convention on the Continental Shelf

1963 Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under the Sea

1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (i.e., London Dumping Convention)

1972 Convention on the Regulations for Preventing Collisions at Sea

1972 United Nations Declaration on the Human Environment

1972 Agreement on the Conservation of Polar Bears

1972 Convention on the International Trade in Endangered Species of Wild Flora and Fauna

1975 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological and Toxic Weapons and Their Destruction

1982 Convention on Wetlands of International Importance Especially as Waterfowl Habitat

Canada has not, however, ratified these conventions:

1958 Convention on the High Seas

1958 Convention on the Territorial Sea and Contiguous Zone

1958 Convention on Fishing and Conservation of the Living Resources of the High Seas

1969 International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties

1969 International Convention on Civil Liability for Oil Pollution Damage

1971 International Convention on the Establishment of an International Fund for Oil Pollution Damage

1971 International Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Materials

1973 International Convention for the Prevention of Pollution by Ships

1978 Convention on the Standards of Training, Certification and Watchkeeping of Seafarers

1982 United Nations Convention on the Law of the Sea

Although Canada supports the intent of many of the latter conventions, there are reasons for Canada's dissatisfaction with those that it has not ratified. In a number of instances, Canada was concerned that the wording of the agreement was neither strong enough nor comprehensive enough. This country did play a significant role in the development of the United Nations Convention on the Law of the Sea, especially Part XII, "Protection and Preservation of the Marine Environment." The Law of the Sea has not yet been ratified by Canada but this is not to say that Canada does not abide by many of its provisions. In fact, it can be argued that Canada has already satisfied the minimal requirements of the treaty (McDorman et al., 1981). However, it could also be argued that only maximal compliance will ensure sustainable development of our exclusive economic zone and protection of the international area beyond it.

The second influence on the legal aspects of marine environmental quality is the role of the federal government. The Canadian government must be cognizant of its responsibilities in the international area and adapt its legislation accordingly while providing leadership and maintaining its jurisdictional position vis-à-vis the provinces. As discussed earlier, the division of jurisdictions created by the British North America Act and since ratified by the Constitution Act of 1982 has been problematic for the management of marine resources and the protection of water quality in coastal areas. Some of the difficulties have been overcome by agreements to coordinate efforts by transfer of administrative responsibility (for example, for aquaculture) and by creating new bilateral institutions to manage development (for example, offshore exploration for oil and gas).

The federal government has enacted many statutes to protect, conserve, and manage marine resources and their use. Table 2 lists many of these along with the

Table 2. The Involvement of Federal Agencies in Marine Environmental Protection and Conservation

Activity	Department	Legislation
Environmental protection	Environment	Fisheries Act (Section 33) *Ocean Dumping Control Act *Environmental Contaminants Act *Canada Water Act *Clean Air Act
	Indian and Northern Affairs	Public Lands Grant Act Territorial Lands Act
	Energy, Mines and Resources	Oil and Gas Production and Conservation Act
Habitat protection	Fisheries and Oceans	Fisheries Act
Water quality management	Environment	Canada Water Act
Commercial and sport fishing management	Fisheries and Oceans	Fisheries Act Territorial Seas and Fishing Zones Act Coastal Fisheries Protection Act
Wildlife management and conservation	Environment	Canada Wildlife Act Migratory Birds Convention Act
Control of agricultural pesticides	Agriculture	Pest Control Products Act
Construction of fishing harbours	Fisheries and Oceans	Recreational and Fishery Harbour Development Act
Dredging	Public Works	Ocean Dumping Control Act
	Transport Environment	Navigable Waters Protection Act
Shipping, sewage discharge, oil spills	Transport	Shipping Act Arctic Waters Pollution Prevention Act
Oil and gas exploration	Energy, Mines and Resources	Oil and Gas Production and Conservation Act
Mineral exploration and offshore mining	Energy, Mines and Resources	Canadian Petroleum Resources Act

Table 2. The Involvement of Federal Agencies in Marine Environmental Protection and Conservation (cont'd)

Activity	Department	Legislation
Ports and harbours	Transport	Public Harbours and Port Facilities Act
	Canada Port Corporation	Canada Port Corporation Act
Marine parks	Environment	National Parks Act

* To be included in the Canadian Environmental Protection Act (CEPA).

activities controlled or managed and the agencies involved.

The federal government's diverse legislative base that touches on the marine environment can and does result in conflicts between its own agencies. As an example, the minister of the environment is assigned responsibility in the Government Organization Act (as amended 1978-79) for the coordination of policies and programs respecting the preservation and enhancement of the quality of the natural environment. This presumably includes the marine environment. The minister of energy, mines and resources has been assigned responsibility for the promotion and development of energy resources in the offshore but also controls pollution arising from such activities. To resolve such conflicts and those with other levels of government and other users requires answers to two questions: Can effective mechanisms be established to ensure the integrity of ecosystems in the marine environment while optimizing economic benefit? And, which minister has the ultimate responsibility for environmental protection?

Third, we must take into account provincial responsibilities for property and civil rights as well as local and private matters. The provinces have authority under the constitution to regulate land use, air and water pollution control, waste disposal on land, and industrial and municipal developments. As such, they play an important role in the protection of coastal waters by ensuring that activities initiated on land by individuals, industries, or municipalities do not harm marine resources or interfere with uses. The rationale for doing so, even though the marine environment below the low-water mark is within federal jurisdiction, is that the resources and uses of the coastal zone generate direct social and economic benefits for the provinces.

However, there is a debate in Canada as in other parts of the world regarding appropriate strategies for regulating the quality of coastal waters. The federal government has favoured uniform emission standards. In this approach, technological controls are installed at the source, that is, on the pipe that is discharging pollutants into the water. The standard that must be met by industry is based on best practicable technology and specific requirements are described in regulations and guidelines.

The other strategy, recognized primarily by the provinces, is based on the assimilative capacity of the ocean. The argument here is that the marine environment has the

capacity to receive contaminants up to a certain concentration without damage. It involves defining environmental quality objectives for receiving waters and then setting standards that are applied to individual discharges. Promoters of this strategy argue that it is scientifically sound and avoids unnecessary expenditures when there is no evidence that discharges are causing damage to quality, resources, or uses. Opponents claim that this is a "soft option" for industries and municipalities and puts the marine environment at risk because we do not have sufficient knowledge of marine ecosystems and sufficiently sensitive, reliable, and practical techniques to measure changes induced by human activities in environments receiving low-level discharges.

These two strategies have been debated in the courts in Canada during cases involving oil, sewage, mine wastes, and food-processing wastes. As might be expected, neither strategy has emerged as the definitive approach sanctioned by the courts. In fact, the courts may not be the most appropriate forum for such debates.

The economic dimension

Clearly, marine areas are important sources of employment and income from tourism, recreation, and commercial exploitation of resources. A recent economic overview of Canada's oceans published by Fisheries and Oceans Canada states that "more than $8 billion and 140 000 jobs are directly attributable to the use of Canada's oceans and ocean resources" (Fisheries and Oceans Canada, 1987b).

The ocean sector activities assessed in the preparation of the overview included fisheries, oil and gas, merchant shipping, shipbuilding and repair, and manufacturing and services. Fisheries, which represent 30 per cent of the sector, centre on a $2.4 billion commercial fish production involving 76 000 fishermen and 24 000 processing plant workers. The number of vessels exceeds 34 500. Although these figures are small in the national context, they represent important contributions to provincial and local economies. In addition to the traditional commercial fisheries, mariculture is going through a period of growth. Barring problems, such as that caused by domoic acid in some east coast molluscs in 1987, sea use conflicts, and pollution caused by land-based activities, that growth is expected to be considerable. However, reports of sickness caused by marine products can have significant economic impacts on harvesters, processors, and communities dependent on those industries. Finally, recreational fisheries contribute substantially to local and provincial economies through direct expenditures and taxes.

Oil and gas exploration in offshore areas of the Mackenzie Delta and Beaufort Sea, the Arctic Islands, Hudson Bay, the Grand Banks, and the Scotian Shelf contributed $7 billion of economic activity during 1981-86, $2 billion of which was spent in 1985. The money paid for the drilling and related onshore undertakings, environmental impact assessments, technology development, and research programs. A substantial portion of the money for research came through the Environmental Studies Revolving Fund, which also played a significant role in the identification of research priorities. Contributions to the fund are levied on oil companies on the basis of the area of offshore territory they have leased for active exploration purposes.

Merchant shipping is also an important marine industry, although the Canadian merchant carriers are small compared with international shipping lines. The 320 merchant carriers in Canada own approximately 2000 ships, employ 16 500 seafarers, and generated a gross revenue of $2.3 billion in 1984.

Shipbuilding and repair, which together generated a modest $1 billion in 1985, are increasing as a result of initiatives to strengthen the Canadian navy and will receive a boost if offshore hydrocarbon reserves are developed.

The manufacturing and marine services industries are a relatively small but expanding part of the ocean sector. There

are approximately 500 companies that provide oceanographic and hydrographic equipment, submersibles, high-tech instruments, and a range of services in engineering, surveying, and biological and physical sciences, among others. These industries are capable of competing internationally but remain dependent to a large degree on contracts from the federal government.

The federal government's own marine-related programs and projects, involving transportation, fisheries management, environmental protection and conservation, national defence, northern development, and science and technology development, generate more than $3 billion and employ 30 000 people (including the navy).

But these amounts do not reflect the total value of the marine environment's contribution to the economy. Tourism and recreation involving coastal parks, beaches, accommodation, marinas, sail and motor boats, and all related expenditures are not taken into account in the analysis (Fisheries and Oceans Canada, 1987b). As leisure time and disposable income increase, so will use of our limited coastal parks and beaches.

All uses of the ocean and coastal resources do not depend on as high a level of environmental quality as recreation and tourism do. We know how to measure this quality biologically, chemically, and aesthetically, although few objectives, criteria, and standards have been established. If we insist on a high level of quality, conflicts -- for example, between waste disposal and swimming and between waste disposal and shellfish harvesting -- will increase. Already the advent of mariculture has brought many simmering issues to the boil. Mariculture applications are pitting neighbour against neighbour at community meetings. If government attempts to foster this new industry for the economic activity it brings are to succeed, new techniques such as mediation to resolve conflicts over specific sites and extensive sea-use planning will have to be employed.

The marine environment also has emotional and spiritual value that cannot be measured in dollars and cents. Nor can we measure the value of its role in supporting production of fish and other species on a sustainable level and in driving atmospheric processes. Can we put a dollar figure on a coastal estuary, or on the value of a clean harbour in terms of its attractiveness as a site for new industries, a location for conferences, a destination for tourists? How broadly should we cast our net in considering the economic value of such an area in light of the fact that future oppportunities may be lost? All these questions of value must be considered when we make decisions about exploiting marine resources.

The technological dimension

Until quite recently, the uses of the marine environment have been limited to shipping, the capture fishery, waste disposal, and some recreational use of the coastline. It remains, in many ways, a frontier area similar to space. But technological advances, especially since World War II, have led to other uses. Shipping in ice-covered waters is being assisted by a range of new technologies including ship design, hull construction, and radar. Oil and gas exploitation, ocean mining, aquaculture, and energy extraction from the ocean's reservoir of stored heat and constant motion are being made possible through technology development.

Some of these uses are not yet commercially viable and technological limitations are only one of the constraints. Our ability to use tides has not yet been fully tested nor are the environmental impacts of large-scale tidal power developments fully understood. Intensive aquaculture activity can generate large quantities of waste materials resulting in aquatic impacts, but technologies may assist in the use and dispersal of these wastes. Manganese nodules and new sea-floor vents surrounded by metalliferous sediments are attracting the attention of mining companies; the extraction of these nodules and sediments could create serious waste disposal difficulties.

Given that the development of the necessary technology to exploit new marine resources is probably only a matter of time and money, and that current uses are already

placing stress on the marine environment, especially near the coasts, what standards should apply to the technology being developed?

The scientific dimension

Marine scientific research is becoming an increasingly important ocean use in its own right as we try to understand global processes, assess the ecological impacts of human activities, and define and manage the generic resources of the ocean. But more importantly, research is critical to the environmentally appropriate development of marine resources and the management of ocean uses.

> The deliberate development of marine science and technology is thus an important aspect of the means of achieving our national goals. In fact, while the present level of our marine scientific and technological activity has achieved a certain theoretical appreciation of the oceans, it has not been sufficient to permit even a general description of the environmental situation which will be affected. To proceed with resource and secondary industry "development" without a simultaneous serious effort to obtain the very detailed scientific understanding of the ecosystem that environmental control implies would be seriously irresponsible. (Stewart and Dickie, 1971).

The issues faced by scientists in responding to the demands of developers and managers include the following:

1) Quality criteria and standards

To enable regulatory agencies to set scientifically sound standards for uses of the marine environment and protection of marine species, criteria must be established through cause-and-effect studies involving toxicology and ecology. The difficulty is to assign priorities among studies so that limited resources are expended effectively.

2) Quality control in analysis and collection

The international character of the ocean has required extensive national and international programs (for example, those of the International Council for the Exploration of the Seas) that assess environmental quality and permit the information generated by research and monitoring by different laboratories to be compared. The resulting reliable and comparable data allow scientists to analyse trends in environmental quality on global, national, and regional bases.

3) Data management and information retrieval

Those who manage the marine environment need to coordinate, integrate, and understand marine and coastal information held by federal, provincial, and local agencies, and their systems for managing information must permit them to identify gaps in the data. Various systems have been tried on all three coasts but there is as yet no national plan to test and evaluate promising systems for managing and retrieving information.

4) Marine monitoring

Compliance monitoring is relatively straightforward once effluent concentrations have been determined and analytical methods established. Effects monitoring and trend monitoring are also viewed as a integral part of any management program for maintaining the quality of the marine environment. But any interpretation of results gathered during these monitoring programs depends on an understanding of baseline conditions and the natural variability of the ecosystems. Data essential for such an understanding do not exist for many coastal and open ocean areas.

5) Assimilative capacity

There has been international debate on the appropriate basis for regulating pollutants that enter the ocean. On one side are the proponents of uniform emission standards and on the other the suppporters of the assimilative capacity approach. Is one of these approaches preferable to the other, or should we go beyond them both and foster an approach that emphasizes comprehensive management of waste particularly by minimizing the quantity we produce?

6) Assessment of cumulative effects

Although our capacity to assess the impacts of specific projects is improving, the same cannot yet be said for the prediction and

evaluation of cumulative effects. These effects accumulate over time or result from multiple, often minor, projects undertaken at one time in the same geographical area. In either case, significant disturbance or pollution can result. The Canadian Environmental Assessment Research Council has identified the need for research programs to improve our understanding of these effects, in particular for programs oriented to the coastal environment.

7) Ecotoxicology

One objective of ecotoxicology is to enable an early, cost-effective prediction of hazard at an acceptable level of certainty, to guide regulatory and industrial decision-making (Maki, 1983, in Wells and Côté, 1988). Traditional 96-hour lethality tests have been helpful tools in regulating waste discharges but they have limited value in assessing the ecological effects of effluent discharged into marine waters. New, sensitive techniques are being developed for use in laboratories and in the field, but more effort and funding are required to permit extrapolation of laboratory results to field conditions.

There are a number of science policy questions that must also be addressed as government, industry, and the public work toward a holistic approach to the planning, protection, and management of the marine environment. Some of these questions are:

What is an acceptable level of monitoring for planning the use of the sea, for measuring its effects, and for analysing trends?

What are the most cost-effective and ecologically effective biomonitoring techniques?

What is a reasonable balance between the collection of baseline data for use in the future and the collection of data to answer today's management questions?

Should the private sector and users generally shoulder more of the burden for supplying basic research and long-term monitoring of the marine environment?

What strategies should be used to stimulate more research into understanding the ecotoxicological effects of marine contaminants?

How can agencies and universities collaborate in the establishment of interdisciplinary marine programs at the graduate level?

Is it reasonable to expect that scientific studies should be assigned greater weight in decisions made about marine resources and their use?

How can scientists be encouraged to take part in policy debates and communicate the complexities of marine studies to the public?

What levels of risk to the environment are acceptable for new uses of the ocean?

What assessment and monitoring systems must be implemented to ensure that the environmental capacity of coastal waters is not exceeded?

Should independent assessment of compliance and effects monitoring data be undertaken to provide guidance and oversight?

Given that all wastes cannot be eliminated, what scientific information is needed before a decision can be made on the most environmentally sound disposal site, with the ocean as one possibility?

The role of politicians, supported by policy makers and managers, is to ensure that the risks and benefits are distributed fairly in society. The scientific issue, then, is (1) how can risk be defined and measured in a fluid medium where pollutants do not act alone and often act synergistically with physical alteration of marine habitat? (2) On what degree of confidence is that measurement based? (3) How can that information be usefully interpreted for managers, policy makers, and the public?

CONCLUSION

This paper has attempted to define the nature of marine environmental quality in order to gauge its significance as a topic for further consideration by the Science Council of Canada. There are clearly many aspects of the issue that warrant further attention but first the inertia of existing institutions and disciplines must be overcome.

The degree to which the questions posed are substantially different from other questions of environmental planning and management and, thus, require special attention by the Science Council of Canada, is debatable. However, I believe a number of topics do require further consideration. Many of these concern the appropriate role of science in policy- and decision-making on matters affecting the marine environment.

1. The new and potential uses of the marine environment will reduce the quality of the environment. This tradeoff must be fully integrated into the planning and design of marine uses and technologies.

2. Because natural variability is so large in the ocean we must improve our capacity to predict effects. Decision-making based on the principle of sustainable development requires a better understanding of marine ecosystems.

3. We need to develop tools to assess and manage cumulative impacts of discharges and uses. In coastal areas in particular, it is the cumulative impacts of the large number of developments that are most damaging.

4. Monitoring for contaminants that may harm consumers of food from the sea has been minimal in the past. As fish consumption increases and aquaculture expands, industry and government must develop more-comprehensive monitoring programs.

5. More interdisciplinary educational programs in marine affairs and marine resource management are needed.

6. As evidenced by recent events associated with proposed hydrocarbon exploration on Georges Bank, the environmental assessment and decision-making processes must be improved. As a corollary, the role of scientific information in that process must also be clearly established.

7. We need to develop mechanisms for resolving conflict among such uses as shipping, dredging, aquaculture, hydrocarbon exploration, or marine parks, wherein the most appropriate information would be made available to stakeholders.

8. Effective mechanisms must be found for sharing information by government agencies for planning and programming purposes, to ensure that the quality of the marine environment and, therefore, its long-term social and economic benefits are not compromised.

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